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Installation and User Manual

Solar Power Inverter Module - Hybrid

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1 Safety Information

The present manual contains important instructions for safety operation, start running into exploitation and operation with complete units type SPIM / H.

This manual has to be kept together or near the equipment any time!

Used symbols and warning signs:

DANGER

DANGER means risky situation which, if it is not avoided, can bring to death or to serious injury.

ATTENTION

ATTENTION refers to cases, which are not connected with human injury. Not conforming to this warning sign can bring to material damages.

1.1 Warnings for danger and attention

DANGER

Read and understand this manual before installing or operating the SPIM / H drive. Installation, exploitation and maintenance of the unit must be performed only by qualified personnel.

DANGER

Regional standards for installation must be observed.

DANGER

DO NOT touch unshielded components or terminal strip screw connections with voltage present.

DANGER

Install and close all covers before applying power or starting and stopping the drive.

DANGER

The unit operates with voltages, dangerous for human life. DC capacitors of the unit stay under voltage even, if the unit main supply is turned OFF.

After turning OFF the main supply of SPIM / H unit, please wait 10 minutes to allow the DC bus capacitors to discharge!

DANGER

The unit operates with voltages, dangerous for human life. The strings from photovoltaic modules can be under voltage, when the circuit breaker of the unit is OFF and the fuses of the strings are taken out.

The DC link of the unit stays under voltage even if the unit's main DC circuit breaker is switched OFF.

After turning OFF the SPIM / H unit, please wait 10 minutes to allow the DC bus capacitors to discharge!

DANGER

If some information is not clear, please, contact with the service center of "ELECTROINVENT" LTD!

ATTENTION

Loss of warranty!

The unit must not be damaged, as well as it is forbidden to make holes on it. Any transport damage has to be established and reported to supplier before unit installation.

1.2 Warranty

The data and instructions for assembling and maintenance, given in this manual, are revised regularly and all corrections are included in the next issues. In case of breaking the assembling instructions, the warranty claims will not be accepted. We cannot bear any responsibility also in cases of incidents and material damages, caused from wrong use, as well as from actions of not authorized persons with resulting from these consequences.

2 Introduction

Solar Power Inverter Module / Hybrid (SPIM / H) are a variable frequency drives for three phase induction motors in solar pumping systems. The inverters have a hybrid power input. They could be supplied simultaneously from a 1-phase AC power grid and from a PV array (*Figure 2.1.*).

Example diagram of SPIM / H installation:

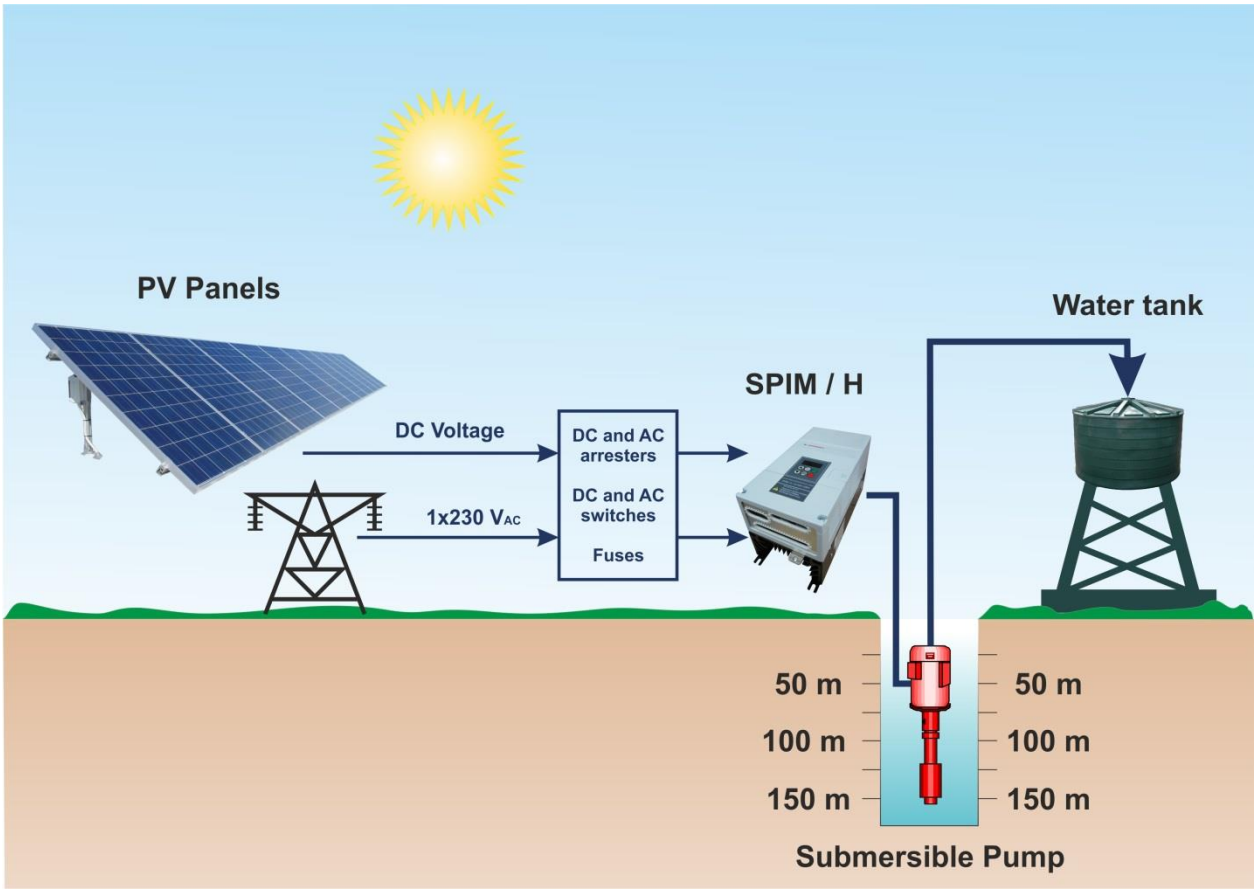


Figure 2.1. Example diagram of a typical SPIM / H application

The inverter module works in a proportional mode, when it is supplied from both, an AC grid and PV panels, the device consumes the maximum possible energy from the PV array and, if the solar energy is not enough to feed the pump, then it consumes the rest necessary energy from the AC power grid.

The SPIM / H module could be supplied only from one power source. For example, only from a PV array. The AC power grid could be switched on/off from an outside automation system only when the customer needs it.

The SPIM / H module must be installed properly, with the needed protection devices, between the power sources and the inverter. For more detailed information regarding to the drive power connections, please see *Table 3.3* and *Figure 3.4*.

3 Hardware Description

3.1 Technical Parameters

The basic technical parameters of SPIM / H are listed in *Table 3.1*.

Table 3.1. Technical parameters

Inverter Model SPIM / H					
Pos.	***Technical Parameter Description***	***Units***	***Parameter Value***		
1	Applicable Motor Power	kW	0.8	1.5	3.0
2	Input AC Grid Voltage	V_{AC}	230 / 1-phase		
3	AC Grid Voltage Frequency	Hz	50 / 60		
4	Input AC Current (max)	A_{rms}	6	11	22
5	Input PV Voltage	V_{DC}	350 - 580		
6	Open Circuit PV Voltage	V_{DC}	575		
7	Input DC Current (max)	A_{DC}	8	16	16
8	Output Voltage	V_{AC}	0-230 / 3-phase		
9	Output Voltage Frequency	Hz	0 – 50Hz (max 70Hz)		
10	Rated Output Current	A_{rms}	4	7	14

3.2 SPIM / H Label with Technical Parameters

The label with the main technical parameters of the unit is located on the right side of the inverter module. The label is shown on *Figure 3.1.*

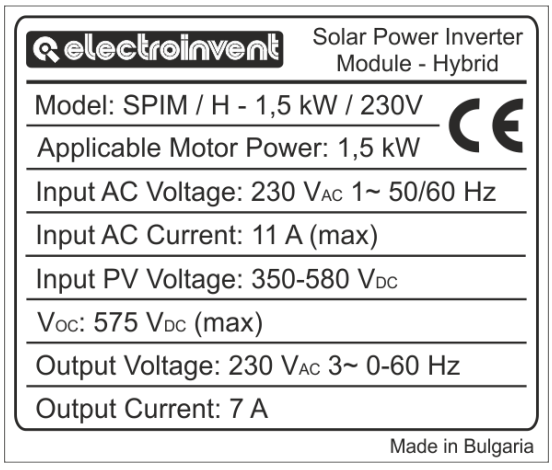


Figure 3.1 SPIM / H label with technical parameters

3.3 Mechanical Installation

The SPIM / H unit has to be mounted on the wall or on the frame. The inside parts of the inverter module must be protected from water or other liquid substances, even during the installation.

The mounting dimensions of the inverters are shown in the *Table 3.2* and *Figure 3.2* down below.

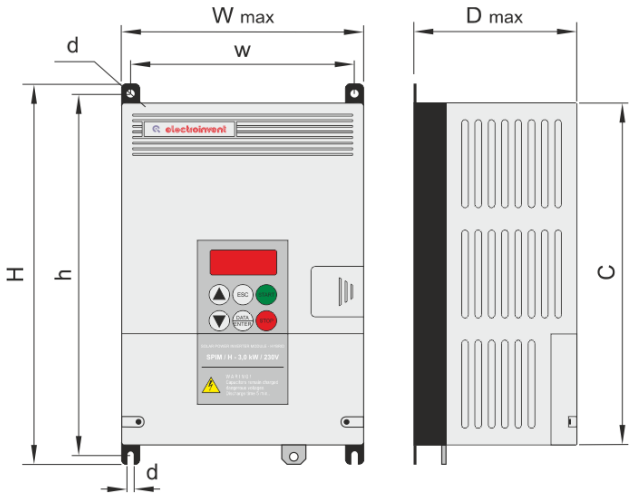


Figure 3.2 Overall and mounting dimensions

Table 3.2 Overall dimensions

Type of inverter:	H (mm)	W (mm)	D (mm)	C (mm)	h (mm)	w (mm)	d (mm)
SPIM / H – 0,8 kW	280	128	140	250	265	105	6
SPIM / H – 1,5 kW	280	128	140	250	265	105	6
SPIM / H – 3,0 kW	280	128	140	250	265	105	6

The following steps (*Figure 3.3*) must be complied while the SPIM / H device is mounted:

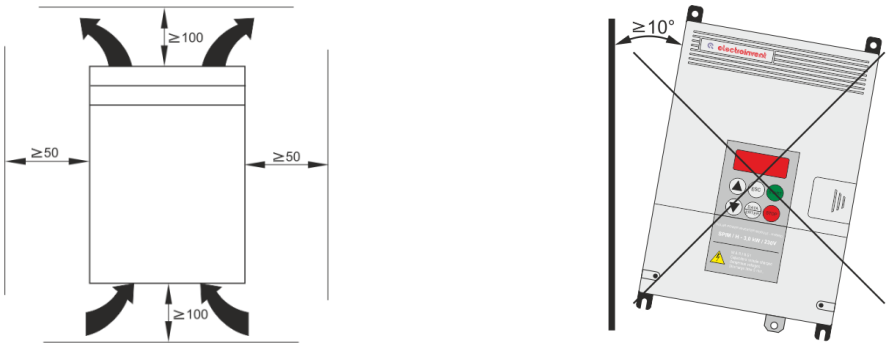


Figure 3.3 Mounting a SPIM / H device

3.4 Power Connections

Power connections of the drive are shown on *Figure 3.4, Figure 3.5* and *Table 3.3* down below:

Table 3.3 Input / Output interface of the inverter module

Connector Designator	Pole №	Connector Pole Name	Description	Comment
CON11	1	PE	Protective Earth	$230V_{AC}$ 1-phase
	2	N	Neutral	
	3	L	Line	
CON12	1	PV+	PV Input +	$350\text{-}580V_{DC}$
	2	PV-	PV Input -	
CON13	1	U	Output Phase U	$0\text{-}230V_{AC}$ 3-phase
	2	V	Output Phase V	
	3	W	Output Phase W	
	4	PE	Protective Earth	

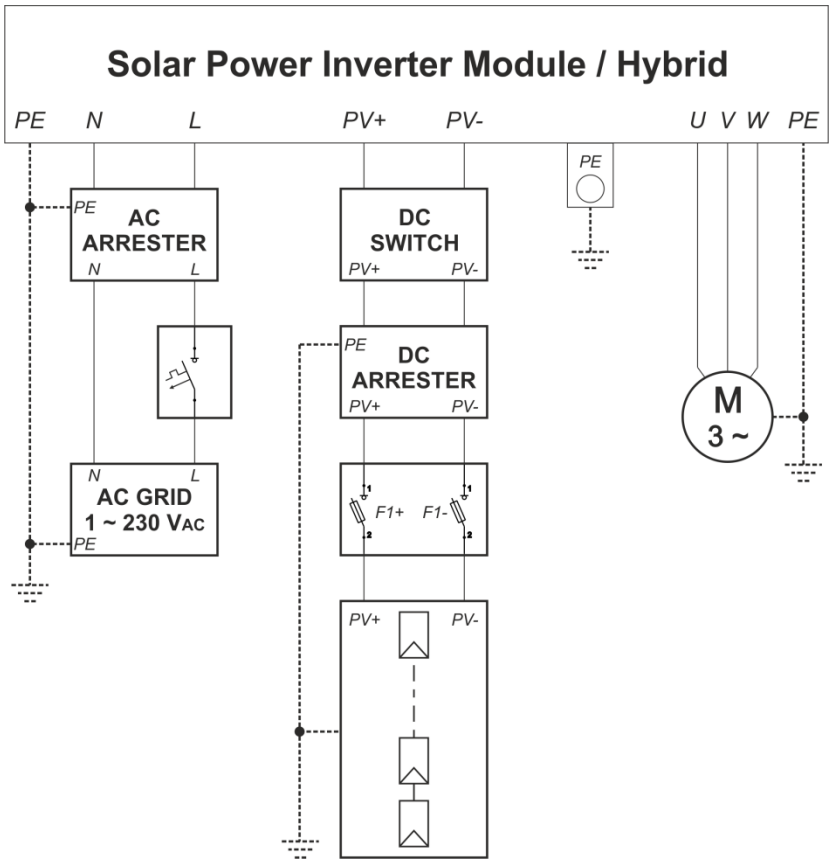


Figure 3.4 SPIM / H block diagram of power connections

Note: For more detailed information regarding to positions of the drive power connections on the main board, please see *Figure 3.5*.

3.5 Input – Output Interface Description of the Inverter Module

The Solar Power Inverter Module - Hybrid – “SPIM / H” has the following built in Input / Output interface, which can be used for configuring the unit is a part from bigger automation system. The Input / Output interface of the inverter module is described in the *Table 3.4* below.

Table 3.4 Input / Output interface of the inverter module

Connector Designator	Pin №	Pin Signal Name	Description
CON21	1	N.C.	Not connected
	2	N.C.	Not connected
	3	TX_RS232	Transmit signal
	4	A_RS485	Data (-)
	5	B_RS485	Data (+)
	6	RX_RS232	Receive signal
	7	+5V_COMMUNICATION	Isolated safety potential (+5VDC).
	8	GND_COMMUNICATION	Isolated safety potential.
CON22	1	N.C.	Not connected
	2	N.C.	Not connected
	3	N.C.	Not connected
	4	A_RS485	Data (-)
	5	B_RS485	Data (+)
	6	N.C.	Not connected
	7	+5V_COMMUNICATION	Isolated safety potential.
	8	GND_COMMUNICATION	Isolated safety potential.
CON23	1	+24VDC_OUT	Isolated safety potential (+24VDC).
	2	DGND	Isolated safety potential.
	3	COM_IN	Common potential for the isolated digital inputs. If the +24V_Safe supply is used for driving the inputs, pins 2 (DGND) and 3 (COM_IN) must be connected to each other.
	4	DIG_IN1	Multifunctional digital input 1. Active level +24VDC. Default configuration is “Start in Auto Mode” (digital input function 3).
	5	DIG_IN2	Multifunctional digital input 2. Active level +24VDC. Default configuration is “Start in Manual Mode” (digital input function 2).
	6	DIG_IN3	Multifunctional digital input 3. Active level +24VDC. Non-configured by default.
	7	DIG_OUT	Open collector type (output transistor permissible collector-emitter voltage +30VDC and collector current 20mA). Non-configured by default.
	8	COM_OUT	Common potential for the isolated digital outputs.
	9	DGND	Isolated safety potential.
	10	+12VDC_OUT	Isolated safety potential (+12VDC).

Connector Designator	Pin №	Pin Signal Name	Description
CON24	1	+10VDC_OUT	Isolated safety potential (+10VDC).
	2	ANA_IN+	Differential analog input hardware configurations: • Differential line 4-20mA. Input resistance 250Ω. • Voltage input: 0±5VDC *(0÷10VDC using offset; see Menu 6 (G) on p. 13).*
	3	ANA_IN-	
	4	ANA_GND	Analog ground.
CON25	1	N.C.	Not Connected
	2	REL_OUT_NC	Normally closed contact in relation to the common node 1.
	3	REL_OUT_COM	Common node 1.
	4	REL1_NO	Normally opened contact in relation to the common node 1.

The power connections and the input/output interface from *Table 3.3* and *Table 3.4* are shown on *Figure 3.5.*

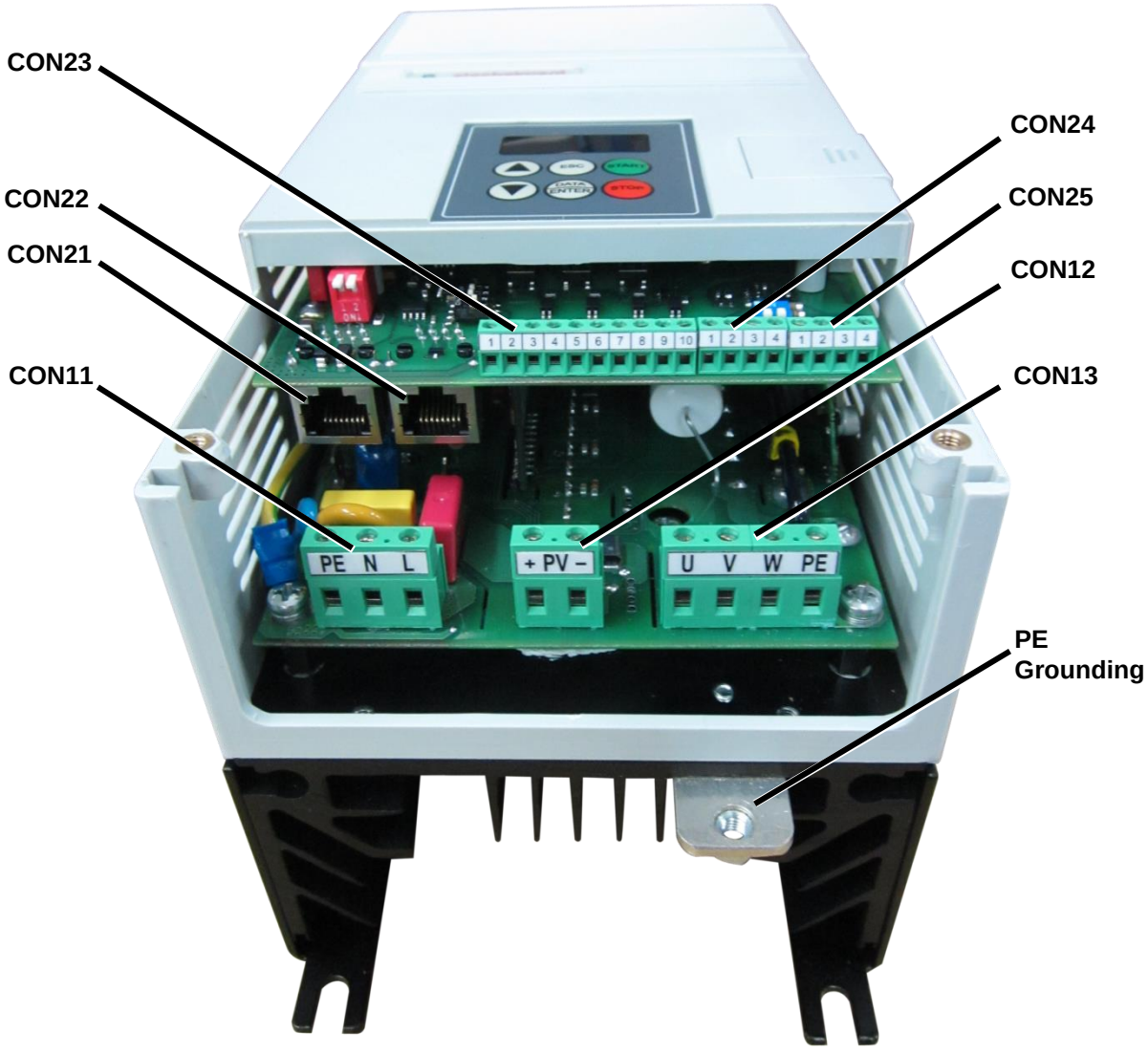


Figure 3.5 Input / Output interface of SPIM / H device

The DIP switches descriptions are shown in the *Table 3.5* below.

Table 3.5 DIP switch description

DIP Switch Designator	SW Pos.	Switch state	Combination Description	Comment
SW1	1	ON	Termination resistor with value 120Ω is connected to the RS-485 network.	
	2	ON		
	1	OFF	The termination resistor is disconnected.	
	2	OFF		
SW2	1	ON	RS-232 communication is available through CON21.	All other switch combinations are not functional.
	2	ON		
	3	OFF		
	4	OFF		
	1	OFF	RS-485 communication is available through CON21 and CON22.	
	2	OFF		
	3	ON		
	4	ON		
SW3	1	ON	250Ω are connected to the differential analogue input for 4/20mA input signal.	The factory setting of the switch is all positions **"OFF"**, because the analog input is specified as voltage input.
	2	ON		
	1	OFF	The 250Ω load is disconnected.	
	2	OFF		

The positions of the DIP switches, on the board, are shown in the *Figure 3.6*.

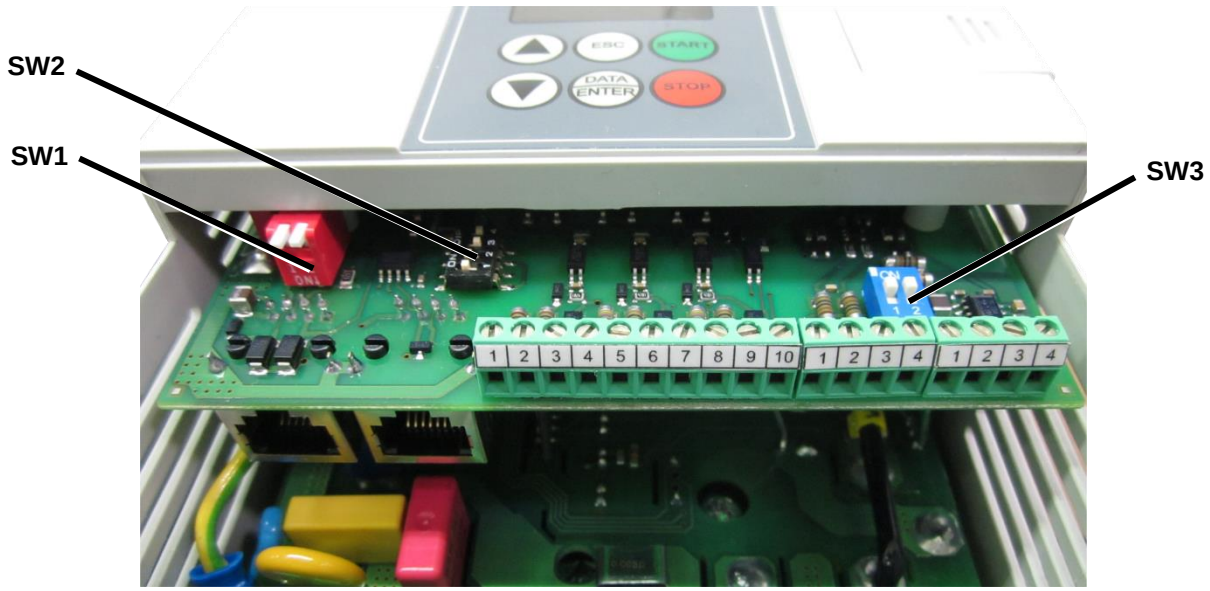


Figure 3.6. DIP switches positions

4 Software Functional Description

4.1 Parameters of the Inverter (Software Rev. 37)

Parameters of frequency inverter are grouped in 12 functional menus, described below.

Table 4.1. – Drive parameters description

4.1.1 Menu 0 (A) - Frequency Set point

№	Parameter	Explanation	MODBUS address	Range		Factory setting
A.00	Freq.Ref Hz	Frequency Reference [Hz]	0x0000	0 - 70	Hz	50.0
A.01	Freq.Min Hz	Minimal operational Frequency [Hz]	0x0001	0 - 50	Hz	35.0

4.1.2 Menu 1 (b) - Display

№	Parameter	Explanation	MODBUS address	Range		Factory setting
b.00	Disp.Par.ID	Choice of variable for visualization: **0** : **voltage** across the capacitor battery **1** : **output phase current** of the inverter/motor **2** : **synchronous speed** of the motor **3** : **output frequency** of the inverter **4** : **drive condition** **5** : **software version** **6** : **state** of digital inputs of the inverter **7** : **state** of digital outputs of the inverter **8** : liquid **pressure**(analog input) **9**: calculated inverter **output line voltage** **10**: calculated motor **power factor**	0x0100	0 - 7	V A rpm Hz - - - -	-
b.01	Displ.Value	Present value of selected variable	0x0101		-	-

4.1.3 Menu 2 (C) - Motor Parameters

№	Parameter	Explanation	MODBUS address	Range		Factory setting
C.00	Unom V	Nominal Line Voltage	0x0200	100 - 420	V	230
C.01	I_nom A	Nominal Phase Current	0x0201	0.5 - 48.0	A	Depends on drive output power
C.02	Pole pairs	Number of Pole Pairs	0x0202	1 - 4	-	2
C.03	Frq Max Hz	Maximal Frequency	0x0203	25 - 65	Hz	55
C.04	Frq Base Hz	Base Frequency	0x0204	25 - 65	Hz	50

4.1.4 Menu 3 (d) - General Setup

№	Parameter	Explanation	MODBUS address	Range		Factory setting
d.00	MainsVtg V	Grid Voltage	0x0300	127 - 440	V	230
d.01	fInvert.kHz	Inverter Switching Frequency	0x0301	1 - 10	kHz	4
d.02	Fan-On Levl	Cooling Fan switch-on level	0x0302	0.00 – 1.00	-	0.73
d.03	Prot.Enable	Activation/Deactivation of - Earth Fault protection(**EF**) - Output Phase Interruption protection(**out**) 0 – both protections disabled 1 – '**EF**' disabled, '**out**' enabled 2 – '**EF**' enabled, '**out**' disabled 3 - both protections enabled	0x0303	0 - 3	-	0
d.04	Stop Mode	Inverter Stop Mode 0 – controlled stop with speed ramp 1 – free(uncontrolled) stop	0x0304	0 - 1	-	0
d.05	Defaults/Save	**1**: Loading of saved backup configuration from flash memory into operational memory **2**: Creation of backup configuration by copying the adjusted parameter values from operational memory into flash memory **3**: Forced copying of adjusted parameter values from operational memory into "automatic" area in flash memory Refer to Chapter **4.3.4** for more details	0x0305	0 - 3	-	0

4.1.5 Menu 4 (E) - Multifunctional inputs

№	Parameter	Explanation	MODBUS address	Range		Factory setting
E.00	AnaInp1 Fnc	Multifunctional **Analog input** In present software version the External Analog Input is used solely for measurement of liquid pressure, no other function can be assigned to it	0x0400	0 – 0	-	0
E.01	DigInp1 Fnc	Multifunctional **Digital input 1**	0x0401	0 – 106	-	2
E.02	DigInp2 Fnc	Multifunctional **Digital input 2**	0x0402	0 – 106	-	6
E.03	DigInp3 Fnc	Multifunctional **Digital input 3**	0x0403	0 – 106	-	0

Refer to Chapter **2.1** for detailed explanation of Multifunctional Inputs configuration and usage

4.1.6 Menu 5 (F) - Multifunctional outputs

№	Parameter	Explanation	MODBUS address	Range		Factory setting
F.00	IoOut1 Func	Function on digital output 1 (open collector)	0x0500	0 – 103	-	0
F.01	IoOut2 Func	Function on digital output 2 (relay)	0x0501	0 - 103	-	1

Refer to Chapter **2.2** for detailed explanation of Multifunctional Outputs configuration and usage

4.1.7 Menu 6 (G) - Analog Input Configuration

№	Parameter	Explanation	MODBUS address	Range		Factory setting
G.00	AnaInp Gain	Analog input Gain	0x0600	0.000–4.000	-	1.00
G.01	AnaInp Ofst	Analog input Offset	0x0601	-9999 +9999	-	0
G.02	Pressure Hi	Liquid pressure threshold-High	0x0602	0.00 - 1.00	-	1.00
G.03	Pressure Lo	Liquid pressure threshold-Low	0x0603	0.00 - 1.00	-	1.00

4.1.8 Menu 7 (H) - Ramp generator

№	Parameter	Explanation	MODBUS address	Range		Factory setting
H.00	Acc x100 ms	Positive acceleration from 0 to f_{ref}	0x0700	0 - 32760	x 0.1s	65
H.01	Dcc x100 ms	Negative acceleration from f_{ref} to 0	0x0701	0 - 32760	x 0.1s	65
H.02	Emg x100 ms	Negative acceleration for emergency stop	0x0702	10 - 1000	x 0.1s	50

4.1.9 Menu 8 (I) - Current limitation

№	Parameter	Explanation	MODBUS address	Range		Factory setting
I.00	IlimLo/Inom	Current limitation – Low level	0x0800	0.60 – 1.70	-	1.35
I.01	IlimHi/Inom	Current limitation – High level	0x0801	0.60 – 2.00	-	1.60
I.02	Ovrld Timer	Timer protection against Overload	0x0802	500-32750	ms	32000
I.03	Ovrld Scale	Overload Current / Rated Current ratio	0x0803	1.00-1.50	-	1.20

4.1.10 Menu 9 (J) – Communication

№	Parameter	Explanation	MODBUS address	Range		Factory setting
J.00	Baud / 100	Choice of speed on RS232 serial port: 9600, 19200, 38400, 57600, 115200 (bit/sec) The value is entered without the two trailing zeroes	0x0900	96 - 1152	baud /100	192
J.01	Parity	Parity control: **0** – No parity control **1** – Odd number of “ones” in each symbol **2** – Even number of “ones” in each symbol	0x0901	0 - 2	-	0
J.02	Stop bits	Number of stop-bits	0x0902	1 - 2	-	1
J.03	Node ID	MODBUS Node Identifier	0x0903	1 - 247	-	1
J.04	Mbs.timescl	MODBUS communication timeout correction	0x0904	0.100-1.900	-	1.000

4.1.11 Menu 10 (L) - V-Hz curve

№	Parameter	Explanation	MODBUS address	Range		Factory setting
L.00	Ustart/Umax.	Output voltage at Zero Frequency	0x0A00	0.00 – 0.20	-	0.00
L.01	Uboost/Umax	Output voltage at Boost Frequency	0x0A01	0.00 – 0.25	-	0.00
L.02	Ubase/Umax	Output voltage at Motor Base Frequency	0x0A02	0.25 – 1.00	-	1.00
L.03	Fboost/Fmax	Boost Frequency	0x0A03	0.000–0.500	-	0.00

4.1.12 Menu 11 (n) - Solar Control

№	Parameter	Explanation	MODBUS address	Range		Factory setting
n.00	SolarPiRegP	Proportional(**P**) Gain of the **PI**-regulator which controls the inverter output frequency	0x0B00	0.000–1.000	-	0.025
n.01	SolarPiRegI	Integral(**I**) Gain of the **PI**-regulator which controls the inverter output frequency	0x0B01	0.000–0.100	-	0.008
n.02	Vtg OC [V]	Open Circuit Voltage of the solar panel (the voltage in non-operational (open circuit) condition. This parameter is used only when multiple inverters are connected to a solar panel string. If a single inverter is connected to the string, then **n.02** should be set to **0**. The Open Circuit voltage is detected automatically in this case.	0x0B02	0 – 800	-	500
n.03	VtgCritical	Proportion of the Minimal allowable operating voltage to the Open Circuit voltage of the solar panel	0x0B03	0.40 – 0.95	-	0.82
n.04	Restrt[sec]	Interval(in seconds) for restarting the inverter	0x0B04	10 - 1800	-	-
n.05	MPPT-To[ms]	MPPT Cycle Time in milliseconds	0x0B05	500-9999	-	2000
n.06	MPPT-Step	MPPT Step	0x0B06	0.000-0.010	-	0.000

4.1.13 Menu 12 (o) - Pump Control

№	Parameter	Explanation	MODBUS address	Range		Factory setting
o.00	Min.PwrFctr	Minimal Power Factor level for “dry run” detection	0x0C00	0.000–0.800	-	0.350
o.01	Tmeout[sec]	Sets the time interval (in seconds) the ‘dry run’ condition must persist before ‘dry run’ protection is activated and the drive is disabled	0x0C01	5–120	-	8
o.02	Restrt[min]	Sets the time interval(in minutes) before automatic drive restart is attempted in case of ‘dry run’ activation	0x0C02	5 – 1440	-	30

4.2 Configuration and Activation of Digital Input / Output Functions

4.2.1 Configuration and Activation of Digital Input Functions

A set of digital inputs is provided to control the inverter. Each digital input can be assigned different function according to the characteristics of the technological process and the customer preferences. This is done by assigning any of the available set of digital input functions to some digital input. All input functions will be listed and explained in this chapter further bellow.

Assigning a function to given digital input is done in **Menu 4** - "**Multifunctional inputs**", where each of the digital inputs is presented by separate parameter. We choose the digital input to which we want to attach a function, and then we set the parameter corresponding to this input to the value corresponding to the needed function.

After a function has been configured (assigned) to a digital input, activation of the input activates also the attached function. Activating the input means to feed an active level (voltage) by closing or opening of contact connected to it. The type of active level (if activating is done by closing or opening) also can be chosen individually for each input – this will be described further below in this chapter.

Summary:
In order to activate some digital input function, you need to attach this function to some digital input, and then the input has to be activated by feeding the chosen active level.

Digital Input Functions

Table 4.2. – Digital Input Functions

№	Name	Description
0	Not configured	There is no function assigned to this input.
1	Emergency stop	By activating of this function the motor stops Until this function is active, inverter cannot be started.
2	Start (Manual Mode)	If voltage is present at the inverter input, we activate Function **2** to start the drive. If Function **2** is permanently active(corresponding input switch permanently ON): - the inverter does not start automatically when input voltage appears. Instead, the inverter control system waits until Function **2** is deactivated, then activation of the function starts the inverter. - In case that the drive is stopped by any electronic self-protection, subsequent disappearance of the fault condition does not restore normal drive operation. Instead, the inverter control system waits until Function **2** is deactivated, then the function activation starts the inverter.
3	Start (Auto Mode)	If voltage is present at the inverter input, we activate Function **3** to start the drive. If Function **3** is permanently active(corresponding input switch permanently ON): - the inverter starts automatically when input voltage appears - In case that the drive is stopped by any electronic self-protection, subsequent disappearance of the fault condition restores normal drive operation.
4	Level above upper limit	If this function is activated(by exceeding the upper limit level of the tank): the inverter stops and the pump stays switched-off until activation of function 6 („Level below lower limit")
5	Level bellow lower limit	If this function is activated(by the water level gone bellow lower limit): the inverter drives the motor on condition that some **Start** function(**2** or **3**) is active and **Emergency stop** function(**1**) is not active. **Note**: if neither **5**, nor **6** functions are configured, the inverter is controlled by the **Start** and **Emergency Stop** functions only.
6	Inverter Output Enable	This function must be activated to enable drive operation. Otherwise Manual Start/Auto Start commands are ignored.

By configuring input functions with numbers (values) shown in above table, activation of given function is done by closing the contact that connects the corresponding digital input to the source of operational voltage. Deactivation becomes by opening of the same contact. In case that the reverse logic is needed (activation by contact opening) the values of functions from the table have to be modified by adding an offset of **100**.

Example 1: We want to assign input function **2**(Manual Start) to digital input **1**, so that this function is activated by closing of a contact.
In Menu 4 "**Multifunctional inputs**" we find the parameter, corresponding to digital input **1**: this is parameter **E.01**.
We give **E.01** the value of **2**. So function **2** is assigned to digital input **1**.
Function **2** is activated by closing the contact, connected to input **1**.

Example 2: We change the conditions in Example 1, so that the function **2** is activated by opening of a contact and is deactivated by closing the contact.
In accordance with the principle, depicted above, we set parameter **E.01** to the value **2**+**100**, i.e. **102**.
So function **2** is assigned to digital input **1**, but it is activated by opening of a contact connected to input **1** and it is deactivated by closing the same contact.

4.2.2 Configuration and Activation of Digital Output Functions

A set of digital outputs provide inverter state feedback.
Each digital output can be assigned some of the available set of digital output functions.
All output functions will be listed and explained in this chapter further bellow.

Assigning a function to given digital output is done in **Menu 5** - "**Multifunctional outputs**", where each of the digital outputs is presented by separate parameter. We choose the digital output to which we want to attach a function, and then we set the parameter corresponding to this output to the value corresponding to the needed function.
After a function has been configured (assigned) to a digital output, activation of the assigned function activates also the related output. Activating of relay output means its transition to active condition (closed or open contact). The type of the active condition (closed or open contact) is configured individually for each input – this will be described further below.

Digital Output Functions

Table 4.3. – Digital Output Functions

№	Name	Description
0	Not configured	There is no function assigned to this output.
1	Ready	This digital output function is activated after drive power-up initialization is complete provided that there is no electronic self-protection activated by some fault condition.
2	Start / Stop	This digital output function is activated, when the inverter is started – A.C. voltage is present on its output terminals. The digital function is deactivated when there is no voltage on the output terminals (the inverter is switched-off). So, the **Start/Stop** output may become active only when some **Start** input function is activated and there is no fault condition present.
3	Pump Running	This digital output function is activated when the inverter is switched on and supplies to the motor voltage with frequency, bigger than the configured minimal operating output frequency of the pump. Active condition of this function is an indication that the motor secures the pump high enough speed to be able to pump the water.

Summary:
In order to activate some digital output, we attach some digital output function to it.
Then, activation of the configured function activates the output to which the function is attached – the output goes to the chosen active state.

By configuring of digital output functions with numbers (values) given in above table, activation of given function leads to closing of contact on digital output, to which this function is assigned. Deactivation of output function leads to opening of the same contact. In case that the reverse logic is needed (opening of contact by activation) the values of functions in the table will be modified by adding an offset of **100**.

Example 3: We want to assign output function **3** („Pump Running") to digital output **0**, so that by activating of the function the relay contact on output 0 is closed.
In Menu 5 "**Multifunctional outputs**" we find the parameter, corresponding to digital output **1**: this is parameter **F.00**.
Then we assign the value **3** to **F.00**. So the output function **3** is assigned to digital output **1**. By activating of output function **3**, the relay on digital output 1 closes its contacts.

Example 4: We change the conditions of Example 3, so that activating of output function **3**, should open digital output **1** contact and deactivating of function **3** should close digital output **1**.
In accordance with principal depicted above, we assign value **3+100** (i.e. **103)** to parameter **F.00**.
So the output function **3** is assigned to digital output **1**, but by activating of the function, the contact is open, and by deactivating it is closed.

4.3 Description of Inverter Menus and Parameters

4.3.1 Menu 0(A) - "Setting of inverter output frequency"

Parameter **A.00** (**Frequency Reference**) sets the maximal output frequency, which the inverter can achieve in case of high irradiance, ensuring enough energy flow from the solar panels.
In lower irradiance conditions the output frequency set point is provided by the 'Solar' **PI**-Regulator which sustains the highest possible output frequency for given irradiance conditions.

Parameter **A.01** (**Minimal operational Frequency**) sets a lower limit for the inverter/pump operation. In poor irradiance conditions the highest achievable output frequency/motor velocity, might be too low for the pump to ensure any water flow. So, the motor/pump would rotate at low speed to no avail. Therefore, normal pump operation assumes that the pump motor rotation speed does not fall below some minimal value at which water flow stops. If the incoming energy flow from the PV panels is not sufficient to sustain this minimal output frequency, then the inverter control system disables the inverter output and the pump stops for certain time interval before a new attempt to accelerate the drive above the minimal frequency is tried.
This retry interval is configured (in seconds) through the **n.03** – **Restrt** [sec] parameter in Menu 11. Automatic restart is launched only in case that the **Automatic Start** input is active.

4.3.2 Menu 1(b) - "Display"

The menu consists of two parameters.
The first (**b.00**) is index, by which can be chosen some of the liable to visualization variables.
The second (**b.01**) is "read-only" parameter (only for reading) in which the chosen for visualization variable appears.
The values, which can accept **b.00**, as well as the corresponding list of variables for visualization, are shown in paragraph 1.2.
For visualization of given variable by operation with the **ConfigMaster** software, the following sequence should be followed:

- It is assigned the desired value of index **b.00** (with this it is choosing the variable for visualization)

- With right button of the mouse should “click” upon first or second column of **Menu 1** and from the open context menu should be chosen “Download Menu **1**”, thus refreshing the content of parameter **b.01**, where the chosen variable in correct format appears

NOTE:
The visualization cell (Parameter **b.01**), can be chosen for continuous observation by a mouse right-click upon the last column on **Menu 1**/ Parameter 01.
Thus the cell colors are changed and the software starts periodical refreshment of its content. Exit from the regime of continuous observation is done by a new right-click upon the same cell on the grid.
Similarly any other read-only parameter can be chosen for continuous observation.
It is not possible simultaneous setting in regime for observation of two or more parameters.

4.3.3 Menu 2(C) - “Motor Parameters”

For the motor control mode „Constant **U/f** proportion”, used in this type of inverters, some of parameters in Menu 2 are important for control of the pump motor, others are used only to calculate the values, which are visualized or are written into the log file, preserved in the internal energy-independent memory of the inverter.
The important parameters for the control of AC induction motor are:

- **C.00** – Nominal line voltage
- **C.01** – Nominal phase current
- **C.03** – Maximal frequency
- **C.04** – Base frequency

Nominal voltage and current, as well as the base frequency can be taken from the motor label or from producer documentation of the pump.
The value of **C.03** (Maximal frequency) can be specified equal or a little higher than the base frequency. This parameter specifies the upper limit, to which can be increased the frequency reference in Menu 0.
Parameter **C.05** – Power factor is used to calculate the active output power of the inverter and can be taken also from the label of the motor or pumps documentation.
Parameter **C.02** (Number of pole pairs) is not substantial for this mode of motor control.

4.3.4 Menu 3(d) - “General Setup”

d.00 – “ **MainsVtg**”
By supply from electrical grid, this is the nominal effective value of the line voltage.
By supply from solar panels, the value of this parameter is specified equal to their nominal voltage (depending from the type and number of in series connected panels), multiplied by coefficient, equal to **0.707** (reciprocal value of squire root of 2)

d.01 – “**fInvert.kHz**”
This parameter specifies the inverter switching (carrier) frequency.
The range for setting is 2-10(kHz).
The main considerations for the choice of switching frequency are:

- higher output frequency of inverter requires also higher switching frequency.
- but higher switching frequency causes higher commutation losses in the inverter power stage.
- lower switching frequency produces higher acoustic noise in the motor.

As the drives for water pumps operate with low output frequency (up to 60 Hz), it is preferred the carrying frequency not to exceed 5 [kHz]. Typical adjustment would be between 2 and 5 [kHz]. The acoustic noise from the motor is of no importance for this type of drives, and relatively low switching frequency helps against overheating of power transistor unit.

d.02 – "**Fan-On Levl**"
This parameter sets the temperature of power unit, at which the inverter cooling fan is switched-on.
Lower value of this parameter secure lower temperature for the fan switching-on. By value zero, the fan will be permanently switched-on, irrespective of the temperature of the power unit

d.03 – "**Prot.Enable**"
The inverter 'Earth Fault' and 'Output Phase Interruption' protections can be masked (disabled) or enabled using this parameter. Possible values of this parameter and their meaning are shown below:

Table 4.4.

Value	*'Earth Fault'*	*'Output Phase Interruption'*
0	disabled	disabled
1	disabled	**enabled**
2	**enabled**	disabled
3	**enabled**	**enabled**

d.04 – "**Stop mode**"
Parameter **d.04** defines the drive behavior on removing the **Start** signal (setting the **Start** input to inactive state) while the pump motor is rotating.
If **d.04** is set to the value of **0**, then the inverter brings the motor to standstill by decreasing the output frequency in accordance with the Deceleration Ramp, configured by parameter **H.01** (controlled stop).
If **d.04** is set to the value of **1**, then the motor coasts freely to standstill (uncontrolled stop).

d.05 – "**Defaults/Save**"
Parameter **d.05** serves mainly to store entire configurations in permanent (flash) memory of the inverter, as well as to restore written configurations.
When the inverter is power supplied, the configuration parameters, specifying the behavior of the drive, are kept in an energy dependent operational memory (RAM).
By switch-off of the power all parameters from the running configuration are automatically saved in energy independent (non-volatile) FLASH memory.
By switching-on of the power, all parameters from energy independent memory (FLASH) are transferred into operational memory. So the inverter configuration is restored from the last switch-off.

This is so-called **"automatic configuration"**, which is preserved and restored automatically, without external command.
Inappropriate changes of configuration parameters could lead to unwanted behavior of the drive compared to the one before the changes. In case that multiple changes are done, reversion to the previous working configuration could be difficult to do "by memory". To secure taking out from such unfavorable situation, it is foreseen a possibility for saving the **"backup configuration".** This configuration is saved in separate zone in flash-memory that is not affected by automatic writing at power-down. It is recommended after change of configuration parameters, by reaching well working configuration, this configuration to be written as a "backup" one. This can be done as on **d.05** is assigned value of **2**: **d.05** = 2(after writing of configuration, the value on d.05 automatically returns to **0**).

So written reserve configuration stays unchanged until not being overwritten in already described manner. Recovering of backup configuration from flash-memory into operative memory is done by setting **d.05** to **1**: **d.05** = 1.
The running configuration can also be written in the flash-memory not only automatically (at power-down), but also forcefully – as on **d.05** is assigned value **3**: **d.05** = 3.
Note: Each of these operations can be performed only in idle inverter state – when the **Start** input is inactive.

4.3.5 Menu 4(E) - "Multifunctional inputs"

Each of parameters E.0 – E.3 in this menu corresponds to one physical input of the inverter.
Input **E.00** is analog and in the present version of the software it is not used.
The other inputs are digital.
Digital inputs **E.01** – **E.03** are multifunctional and each of them can be assigned some of the available digital input functions, as described in **2.1** – **„Configuration and activation of digital input functions"**

4.3.6 Menu 5(F) - "Multifunctional outputs"

Each parameter (**F.00**, **F.01**) of this menu corresponds to one of inverter's two digital outputs.
F.00 corresponds to the 'open collector' output.
F.01 corresponds to the relay output.
Both digital outputs are multifunctional and each of them can be assigned some of available digital output functions, as described in 2.2 – **„**Configuration and activation of digital output functions**"**

4.3.7 Menu 6(G) - "Analog Input Configuration"

Coefficient of amplification, as well as the offset of the analog input of the inverter can be adjusted by parameters **G**.**00** and **G**.0**1.**

Parameters **G**.**02** ("Pressure Hi") and **G**.**03** ("Pressure Lo") determine the drive operation. In case that the pressure in the liquid container is chosen to perform additional control over start/stop commands. When the "Start" (auto or manual) digital input is activated, the drive runs until the signal on the external analog input goes above the High-pressure level, set by **G**.**02**. Then it's disabled and stays so until the signal falls below the Low-pressure level, set by **G**.**03**. If this functionality is not needed, then both **G**.**02** and **G**.**03** should be set to the maximum value of 1.00 – then the drive is controlled solely by the "Start" digital input, as the input signal can never go above the maximal measurable value.

4.3.8 Menu 7(H) - "Ramp generator"

By parameters **H.00** and **H.01** can be specified positive acceleration and negative motor acceleration.
Acceleration is assigned as time for change of output frequency of the inverter

- from 0 to maximal specified frequency for positive acceleration
- from maximal specified frequency to 0 for negative acceleration

The time is assigned in 0.1 second units.
For example adjustment 100 of the time for positive acceleration (**H.00**) corresponds to 100 x 0.1 = 10 (Sec).
This is a small acceleration, corresponding to smooth start-up of the pump and such adjustment for positive acceleration is typical for this type of drives.

Parameter **H.02** assigns negative acceleration, applied in during Emergency Stop.

4.3.9 Menu 8(I) - "Current limitation"

I.00 specifies a 'low limitation' threshold for the motor phase current. In case of exceeding this limit, the motor acceleration is temporarily stopped (the output frequency reference is "frozen" at its present value) until the phase current drops below the low limitation threshold, then the motor acceleration is resumed.

I.01 specifies a 'high limitation' threshold for the motor phase current. In case of exceeding this limit, the output frequency reference is being gradually reduced until the phase current drops below the high limitation threshold, then the motor acceleration is resumed. Both **I.00** and **I.01** are non-dimensional values specified against the adjusted nominal motor current. If sufficiently long acceleration time is set by **H.00** parameter, the pump acceleration goes smoothly, so in practice there is rather small probability of entering any of the current limitation regimes.

I.02 is a parameter which sets a timer for drive overload protection. The overloading protection is activated in case of continuous operation at motor phase current greater than the adjusted 'overload' current of the motor (set by **I.03**). The time is assigned in milliseconds. For example, the adjustment of **I.02** = 15000 means, that the overload protection will be activated after operation longer than **15** seconds at current bigger than the 'overload' value.

I.03 sets the motor current threshold, above which overload timer is started. **I.03** is a dimensionless value: the ratio between the 'overload' current and the nominal motor current.

4.3.10 Menu 9(J) - "Communication"

The **RS485** serial port (**CON15**) operates at fixed communication parameters as follows:

- Speed **9600** bit/sec
- **No** Parity Control
- Number of Stop Bits: **1**

J.00, **J.01** and **J.02** parameters set the communication parameters for the **RS232** serial port (**CON14**)

- **J.00** sets the communication speed. Available values are 9600, 19200 and 38400 bit/sec. The preferred speed value is entered in **J.00** as listed above. The trailing two zeroes are omitted.
  As an example, the 19200 bit/sec speed is set by **J.00** = 192.
- **J.01** sets the parity control: **0**(No Parity), **1**(Odd Parity), **2**(Even Parity)
- **J.02** sets the Stop Bits number: 1 or 2;
  Default **CON14** settings are: **19200**, **N**, **8**, **1**. (number of data bits in character is always 8)
- **J.03** sets the device identifier number in a MODBUS network (MODBUS Node ID). In accordance with MODBUS protocol, possible values range from 1 to 247. Default value is 1.
- **J.04** is a scalar used for modifying the MODBUS inter-frame timeouts from their standard values

This may be needed for interoperation with devices which don't strictly abide by MODBUS standard. Default setting for **J.04** is **1**.00, which ensures standard MODBUS inter-frame timeout.

4.3.11 Menu 10(L) - "V-Hz curve"

The inverter implements the well-known 'Constant Volt per Hertz' control method. The parameters of this menu set the ratio between the amplitude and frequency values of inverter's output voltage.

L.00 and **L.01** configure voltage boost at zero frequency and at the 'boost frequency' respectively (the 'boost frequency' is set by **L.03** parameter). The voltage boost increases motor torque at very low rotation speed at the price of somewhat bigger motor power losses in the low-speed range. For pump drive systems the load at very low rotation speed is inconsiderable, so boosting of output voltage is normally redundant, so **L.00** and **L.01** parameters may keep their default zero values

L.02 sets the ratio between the voltage at the base (nominal) voltage frequency and the nominal motor Line Voltage, configured through Menu 2("Motor Parameters"). Ordinary setting for **L.02** e 1.00 – the voltage amplitude at the nominal frequency is equal to the configured motor line voltage.

L.03 sets the boost frequency value for the U/f curve. According to the considerations given above, Voltage Boost is hardly needed for pump drives, so normally **L.03** may preserve its default zero value.

4.3.12 Menu 11(n) - "Solar Control"

n.00 and **n.01** parameters set respectively the **P**-component gain and **I**-component gain of a Proportionally-Integral Controller(**PI**) Controller which produces the drive output frequency setpoint depending on the measured value of the DC-voltage coming from the PV panels. "Solar" PI-controller prevents the drive from drawing too much power from the PV-panels in case of insufficient solar radiation. So, it reduces the output frequency setpoint if the measured PV voltage tends to fall below some critical threshold. This 'Critical Voltage' threshold is defined as proportion of the PV voltage under load towards the PV voltage in idle state ('Open Circuit' PV voltage, **OC**). So, setting the Critical Voltage presumes knowledge of the 'Open Circuit' PV voltage. 'Open Circuit' PV voltage can be easily measured by the inverter in idle state. But this is true only on condition that there is only one inverter connected to the PV string. If there are two or more inverters supplied by common PV string, automatic determination of the 'Open Circuit' PV voltage is not possible as there is no guarantee that when some inverter is idle, the PV panels are not being loaded by some other inverter.

Parameter **n.02** is used for manual setting of the 'Open Circuit' PV voltage for the case where there are several inverters supplied by a common string of PV panels.
A simple procedure to set this parameter is described below:

1) Put all inverters, supplied by the PV string in 'idle' state.
2) Set one of the inverters into '**Operating Values Observation**' mode (refer to paragraph **6.2.5**).
3) Select 'DC-bus Voltage' as a variable for monitoring and use the displayed value as input for **n.02**.

If only one inverter is connected to the PV string, you set **n.02** to zero. In this case the inverter software automatically sets the PV voltage measured in idle state as 'Open Circuit' voltage.

n.03 parameter configures the relative value of the drive operating DC-voltage(Critical Voltage) towards the "Open Circuit" PV voltage.
Typically the value of the **n.03** coefficient is about 0.80, which means that when the inverter is in operation, its control system tries to ensure maximal possible output frequency without letting the DC voltage drop below 80% of the PV panels OC voltage value.

n.04 – **Restrt** [sec] sets the time interval (in seconds) between two consecutive attempts to accelerate the pump motor above the configured minimal operational frequency.
Refer to the description of Parameter **A.01** (**Minimal operational Frequency**) for more details.

n.05 - and **n.06** parameters configure the **MPPT** (Maximum Power Point Tracking) operation.
MPPT performs continuous automatic correction of the Critical Voltage value (configured via **n.03**) in order to achieve maximal possible frequency on the inverter output. The Critical Voltage value set by **n.03** is internally summed with a correction value which is periodically re-calculated using the well-known 'Perturb & Observe' algorithm. The intervals for calculation of the correction are set in milliseconds, through **n.05** ('MPPT-Timeout'). The perturbation step is set by **n.06** ('MPPT Step').

MPPT operation is possible only in the case of one inverter connected to a PV string.
If several inverters are supplied from common string, MPPT function on each of them should be cancelled by giving the MPPT Step (**n.06**) the value of 0.

4.3.13 Menu 12(o) - "Pump Control"

As continuous operation of the pump system without fluid is considered an emergency, protection against it is implemented in the drive control system. Menu **12** provides parameters for customizing this protection.
There are two decisions to be made regarding the timing of the 'dry run' protection:

a) How long the 'dry run' condition must exist before turning the drive off. This timeout value is set in seconds via **o**.**01** (**Timeout** [sec]) parameter. It shouldn't be too short because transient 'dry run' conditions normally occur during initial drive acceleration. The timeout must not be too long either as prolonged dry rotation may be harmful for the pump. By default the timeout is set to 5 seconds.

b) How long the drive should stay inactive in case it has been turned off due to 'dry run' condition.

This interval is set in minutes via **o**.**02** (**Restrt** [min]) parameter. The maximal value of **o**.**02** is 1440 minutes (24 hours). By default the restart interval is set to 30 minutes.

Besides, a 'Minimal Power Factor' threshold is set which is used for 'dry run' condition detection. Normally you don't need to change the default value of **0.35** set for this **o**.**0**(**Min**.**PwrFctr**) parameter.

But in some rare cases it might need modification, especially if the pump regime allows continuous operation at speed or load substantially smaller than the nominal ones. In such cases faulty activation of the 'dry run' protection may occur. To avoid it, you may need to slightly decrease the **o**.**0** setting.

To help figure out the meaning of this ''Minimal Power Factor' threshold, here is a brief description of the principle on which the 'dry run' protection implementation is based:
Induction motors are notorious for their poor power factor in case of idle running or when driving small loads. The power factor grows up when the motor load increases and reaches values of about 0.80 or even 0.90 and more at nominal load and nominal speed(depending on motor specifications).
So, knowing the power factor value, the 'dry run' condition with respective power factor of the order of **0.20** is easily distinguished from the 'full load' condition with power factor around **0.80** or more.
But if the drive is operated at speed/load much smaller than the rated ones, the power factor at this smaller load may occasionally drop below the default value of **0.35**, so some decrease of **o**.**0** parameter value will prevent unwanted activation of the 'dry run' protection.
In these unlikely cases, setting the proper value of the power factor threshold is facilitated by the Power Factor monitoring capability of the drive system – refer to the description of Menu 1(**Display**) in paragraph 3.2.
Power factor value is monitored by selecting the value of **10** for the Display Index parameter **b.0.**

4.4 MODBUS Communication

4.4.1 Supported Functions of MODBUS Protocol

The system supports MODBUS – functions with the following functional codes:

Table 4.5 – Functional codes

03 (0x03)	Read Holding Registers
04 (0x04)	Read Input Registers
05 (0x05)	Write Single Coil
06 (0x06)	Write Single Register
16 (0x10)	Write Multiple Registers

4.4.2 Addressing of Parameters and Variables of the Drive by MODBUS Protocol

Each of described inverter configuration parameters may be read / modified by standard MODBUS protocol functions.

4.4.3 Principle of Addressing

Two-byte address for access to any configuration parameter is formed this way:

- Most significant byte is the number of the menu to which belongs the parameter
- Least significant byte is the index of the parameter within the menu

4.4.4 Representation of Parameters

Presentation of parameter values inside the MODBUS Protocol Data Units is depicted below. To add clarity, some examples are included (*please, refer to the screenshot on the next page*).
Both Integer and Real configuration parameters transmitted through MODBUS frames are coded as 16-bit integer values.
Representation of any parameter sent over the serial line depends on the adopted position of the Decimal Point (**DP**) for the parameter.
A parameter value is transformed to Integer through multiplying it by a factor, equal to the **N**-th power of 10, where **N** is the **DP** position.

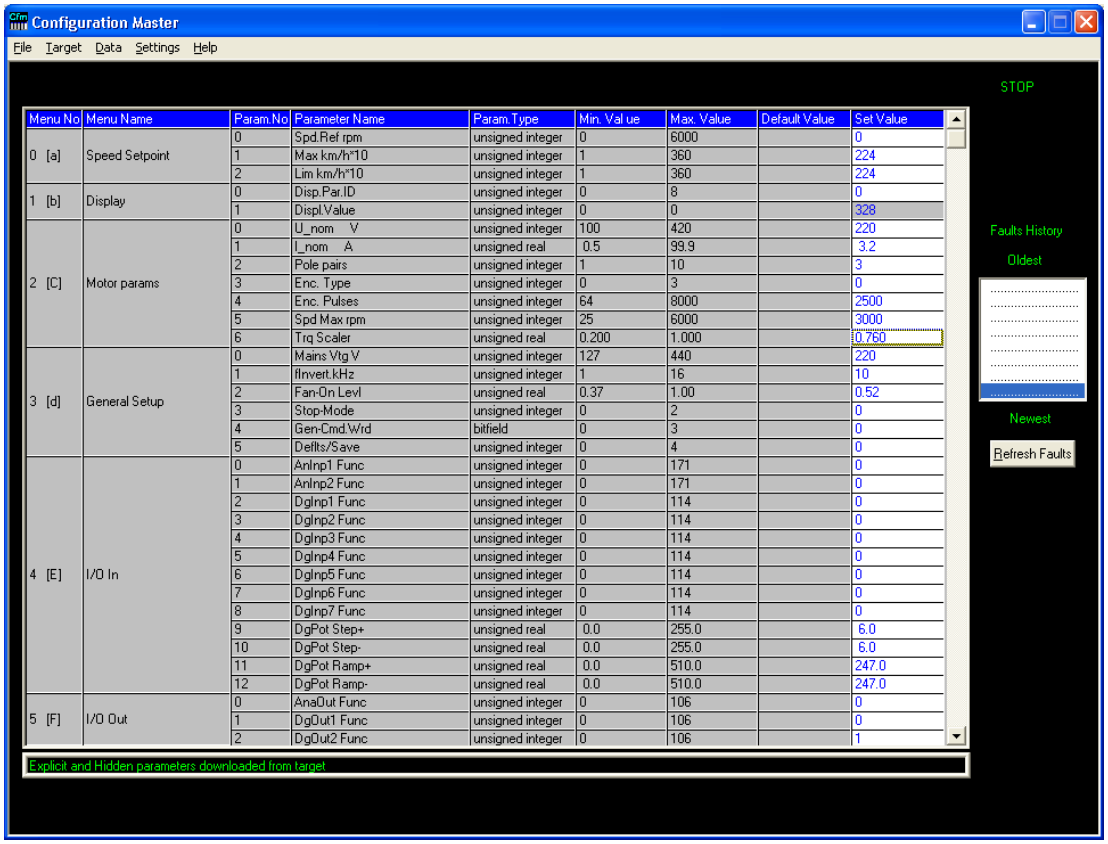
For an Integer parameter DP position is zero, so the transformation factor in this case equals 1 and the value is sent exactly as it appears in the "Set Value" field on the screen.

For a Real parameter the transformation factor, being a power of 10, is big enough to shift the decimal separator to the zero position, converting the Real value into Integer one.

Knowing the DP position for any parameter of interest, the receiving side restores the actual parameter value through dividing the integer number coded in the MODBUS frame by the same transformation factor.

The screenshot on the next page shows part of a Drive Unit configuration downloaded through the "**ConfigMaster"** tool.

Conversion of Real parameter value to Integer one is illustrated with the example of Parameter 6 in Menu 2 (*Figure 4.1*). There are three digits to the right of the decimal separator there, so the DP position is equal to 3. The transformation factor should be 10^3 = 1000. Hence the value of 0.760 is transformed into 1000 x 0.760 = 760 before being inserted into the MODBUS message frame. On reception the real value is restored through dividing of 760 by 1000.



Menu No	Menu Name	Param.No	Parameter Name	Param.Type	Min. Val ue	Max. Value	Default Value	Set Value
0 [a]	Speed Setpoint	0	Spd.Ref rpm	unsigned integer	0	6000		0
		1	Max km/h*10	unsigned integer	1	360		224
		2	Lim km/h*10	unsigned integer	1	360		224
1 [b]	Display	0	Disp.Par.ID	unsigned integer	0	8		0
		1	Displ.Value	unsigned integer	0	0		328
2 [C]	Motor params	0	U_nom V	unsigned integer	100	420		220
		1	I_nom A	unsigned real	0.5	99.9		3.2
		2	Pole pairs	unsigned integer	1	10		3
		3	Enc. Type	unsigned integer	0	3		0
		4	Enc. Pulses	unsigned integer	64	8000		2500
		5	Spd Max rpm	unsigned integer	25	6000		3000
		6	Trq Scaler	unsigned real	0.200	1.000		0.760
3 [d]	General Setup	0	Mains Vtg V	unsigned integer	127	440		220
		1	fInvert.kHz	unsigned integer	1	16		10
		2	Fan-On Levl	unsigned real	0.37	1.00		0.52
		3	Stop-Mode	unsigned integer	0	2		0
		4	Gen-Cmd.Wrd	bitfield	0	3		0
		5	Defits/Save	unsigned integer	0	4		0
4 [E]	I/O In	0	AnInp1 Func	unsigned integer	0	171		0
		1	AnInp2 Func	unsigned integer	0	171		0
		2	DgInp1 Func	unsigned integer	0	114		0
		3	DgInp2 Func	unsigned integer	0	114		0
		4	DgInp3 Func	unsigned integer	0	114		0
		5	DgInp4 Func	unsigned integer	0	114		0
		6	DgInp5 Func	unsigned integer	0	114		0
		7	DgInp6 Func	unsigned integer	0	114		0
		8	DgInp7 Func	unsigned integer	0	114		0
		9	DgPot Step+	unsigned real	0.0	255.0		6.0
		10	DgPot Step-	unsigned real	0.0	255.0		6.0
		11	DgPot Ramp+	unsigned real	0.0	510.0		247.0
		12	DgPot Ramp-	unsigned real	0.0	510.0		247.0
5 [F]	I/O Out	0	AnaOut Func	unsigned integer	0	106		0
		1	DgOut1 Func	unsigned integer	0	106		0
		2	DgOut2 Func	unsigned integer	0	106		1

Figure 4.1. "ConfigMaster" User Interface (Parameter 6, Menu 2)

The following examples illustrate reading / modification message sequences for various parameter formats.

Read Holding Registers (MODBUS Function Code **0x03**)

Menu **2**, Parameter **4**
Reading of **Integer** parameter value **2500** (hex **09C4**)

Table 4.6. - Examples

Request			**Response**		
01 03 02 04 00 01 C4 73			**01 03 02 09 C4 BF 87**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**04**		RegVal_Hi	**09**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**C4**	
RegCnt_Lo	**01**		CRC_Lo	**BF**	CRC
CRC_Lo	**C4**	CRC	CRC_Hi	**87**	
CRC_Hi	**73**				

Menu 2, Parameter 1
Reading of **Real** parameter value **3.2**, presented as **3.2** x **10** = **32** (hex **0020**)

Request			Response		
01 03 02 01 00 01 D4 72			**01 03 02 00 20 B9 9C**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**01**		RegVal_Hi	**00**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**20**	
RegCnt_Lo	**01**		CRC_Lo	**B9**	CRC
CRC_Lo	**D4**	CRC	CRC_Hi	**9C**	
CRC_Hi	**72**				

Menu 2, Parameter 6
Reading of **Real** parameter value **0.760**, presented as **0.760** x **1000** = **760** (hex **02F8**)

Request			Response		
01 03 02 06 00 01 65 B3			**01 03 02 02 F8 B8 A6**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**06**		RegVal_Hi	**02**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**F8**	
RegCnt_Lo	**01**		CRC_Lo	**B8**	CRC
CRC_Lo	**65**	CRC	CRC_Hi	**A6**	
CRC_Hi	**B3**				

Menu 3, Parameter 2
Reading of **Real** parameter value **0.52**, presented as **0.52** x **100** = **52** (hex **0034**)

Request			Response		
01 03 03 02 00 01 25 8E			**01 03 02 00 34 B9 93**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**03**	Starting Address	ByteCount	**02**	Byte Count
Param	**02**		RegVal_Hi	**00**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**34**	
RegCnt_Lo	**01**		CRC_Lo	**B9**	CRC
CRC_Lo	**25**	CRC	CRC_Hi	**93**	
CRC_Hi	**8E**				

Write Single Register (MODBUS Function Code **0x06**)

Menu 2, Parameter 4
Writing **Integer** parameter value **2500** (hex **09C4**)

Request			Response		
01 06 02 04 09 C4 CE 70			**01 06 02 04 09 C4 CE 70**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**06**	Function Code	FuncCode	**06**	Function Code
Menu	**02**	Register Address	Menu	**02**	Register Address
Param	**04**		Param	**04**	
RegCnt_Hi	**09**	Register Value	RegVal_Hi	**09**	Register Value
RegCnt_Lo	**C4**		RegVal_Lo	**C4**	
CRC_Lo	**CE**	CRC	CRC_Lo	**CE**	CRC
CRC_Hi	**70**		CRC_Hi	**70**	

Menu 2, Parameter 1
Writing **Real** parameter value **3.2**, presented as **3.2** x **10** = **32** (hex **0020**)

Request			Response		
01 06 02 01 00 20 D8 6A			**01 06 02 01 00 20 D8 6A**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**06**	Function Code	FuncCode	**06**	Function Code
Menu	**02**	Register Address	Menu	**02**	Register Address
Param	**01**		Param	**01**	
RegCnt_Hi	**00**	Register Value	RegVal_Hi	**00**	Register Value
RegCnt_Lo	**20**		RegVal_Lo	**20**	
CRC_Lo	**D8**	CRC	CRC_Lo	**D8**	CRC
CRC_Hi	**6A**		CRC_Hi	**6A**	

4.5 Electronic Protections of the Inverter

The inverter is supplied with a set of protections, preserving it and the connected motor from harmful conditions:

- **Over-Voltage** (**OSF**)
- **Under-Voltage** (**USF**)
- **Short Circuit** (**SC**)
- **Over-Current** (**OC**)
- **Over-Heating** (**OH**)
- **Over-Load** (**OL**)
- **Earth Fault** (**EF**)
- **Output Phase Interruption** (**out**)

Activation of any protection disables the inverter output and stops the drive. Flashing designation of the active fault protection appears on the drive display.

In case that the drive is configured for Automatic Start, next attempt to start it is initiated after expiration of time interval, set by **n.03** parameter. During this time the flashing fault indication persists even if the fault condition has already gone away.
The next automatic start clears the fault indication and '**rdY**' inscription is displayed again.

If Manual Start mode is configured, the fault state lasts until '**Manual Start**' input is set inactive (OFF). Then '**rdY**' inscription is displayed and the drive can be started by setting '**Manual Start**' input active (ON).

Special treatment is provided for the '**Short Circuit**' and '**Earth Fault**' protections. If any of these faults appear three times in sequence, then the fault condition cannot be automatically or manually cleared and the drive stays disabled until the next power-down/power-up sequence.

'**Earth Fault**' and '**Output Phase Interruption**' protections could be masked.
Each of them can be disabled (masked) by clearing its corresponding bit in **d.03** parameter (Prot.Enable) - please refer to 'General Setup' menu description for details.

4.6 Control Panel

All explicit and hidden parameter values can be browsed and modified through the drive unit control panel. Drive status and some operating values are also monitored through the control panel display.

4.6.1 Outline

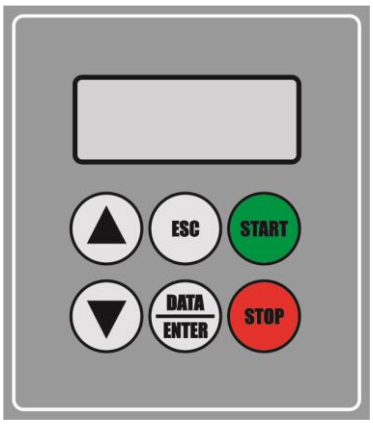


Figure 4.2. – SPIM / H Drive Control Panel

Control Panel consists of 4-digit 7-segment LCD display and 6-key keyboard.
The Keyboard keys assignment is listed below:

Table 4.7. – Control Panel Description

KEY	***Brief description of usage/assignment***
^ (UP)	Scroll through menus/parameters in increasing (UP) direction OR increase parameter values
V (DOWN)	Scroll through menus/parameters in decreasing (DOWN) direction OR decrease parameter values
ESC	Go to upper display level (refer to paragraph **6.2**) OR cancel parameter value modification
DATA/ENTER	Go to lower display level (refer to paragraph **6.2**) OR confirm parameter value modification
START	Start the drive
STOP	Stop the drive

As the brief description above implies, the rightmost key column is dedicated solely to manual starting/stopping the drive.
Navigation through menus/parameters and modification of parameter values is done through the 4 leftmost keys.

4.6.2 Display Levels

Providing the depicted Control Panel functionality is fulfilled through 5 distinct display levels (modes). Moving between the display levels is done through [**DATA**/**ENTER**] and [**ESC**] keys.
The first 4 menu levels are listed below in descending order:

- **MAIN** Display: shows the Drive Status
- **MENUS** Display: shows the menu designation
- **PARAMERTERS** Display: shows the menu designation plus parameter number (index)
- **PARAMERTER Modification** Display: shows the parameter value

The 5-th display level provides monitoring of some selected operating parameter

- **Operating Values Observation** Display: shows the selected operating parameter value

4.6.2.1 **MAIN** Display

After power-up the Control Panel enters **MAIN** Display level. Drive status is shown. Normally, the following status indications are consecutively displayed:

- **CLd** Capacitor battery charging (loading)
- **oFF** Capacitors charging completed, drive initialization still proceeding
- **rdY** Drive initialized and ready for operation
- **on** Drive running

NOTE: After power-up, the '**oFF**' state may persist infinitely in case that the drive is configured for manual control from the terminal board and the '**Manual start**' switch is in active (ON) position. To leave this state you have to cycle the '**Manual start**' switch - put in inactive(OFF) position and then put it in active(ON) position again after '**rdY**' indication appears, as automatic start after Power-on is not permitted in Manual Start mode.

If a fault condition occurs, the activated fault protection inscription is shown in a blinking manner. The fault protection designations are listed below:

Table 4.8 - Faults

Fault Designation	***Fault Type***
OSF	Over Voltage
USF	Under Voltage
SC	Short Circuit
OC	Over Current
OH	Over Heating
OL	Over Load
EF	Earth Fault
out	Output Phase Interruption

You leave the **MAIN** Display level by pressing [**DATA/ENTER**]-key to enter **MENUS** Display level. You may also press the [**^**] (UP) or [**V**] (DOWN) key to go from **MAIN** to **MENUS** Display level.

4.6.2.2 **MENUS** Display

On entering **MENUS** Display level, the first menu designation [**A**] is shown in the leftmost display digit.

You may select the next [**b**]-menu by briefly pressing [**^**] (UP) key.

Next [**^**] – key brief pressing moves you further to the [**C**]-menu etc. until the last menu is reached.

Instead of consecutive brief pressing of [**^**] – key, you may also press and hold it for a while until the needed menu designation appears, then release the key.
You may move through the menus list in opposite direction using the [**V**] (DOWN) key.
To return to the upper (**MAIN**) Display level, press [**ESC**].
When the needed menu is reached, you may press [**DATA/ENTER**]-key to enter the **PARAMERTERS** Display level.

4.6.2.3 **PARAMERTERS** Display

On entering **PARAMERTERS** Display level, the first parameter number [**0**] is shown in the rightmost display digit.
The menu designation still stays in the leftmost display digit.

You may select the next [**1**]-parameter number by briefly pressing [^] (UP) key.

Next [^] – key brief pressing moves you further to the [**2**] - parameter etc. till the last parameter in the selected menu.

Instead of consecutive brief pressing of [^] – key, you may also press and hold it for a while until the needed parameter number appears, then release the key.
You may move through the parameters list in opposite direction using the [**V**] (DOWN) key.
To return to the upper (**MENUS**) Display level, press [**ESC**].
When the needed parameter is reached, you may press [**DATA/ENTER**]-key to enter the **PARAMERTER Modification** Display level.

4.6.2.4 **PARAMERTER Modification** Display

On entering **PARAMERTER Modification** Display level, the presently set value of the selected parameter is shown on the Control Panel display.
To be able to modify the displayed parameter value, you must have been granted appropriate permission by providing a password in advance (refer to paragraph **6.4** for details on Password Protection).

In case that you have acquired modification permission, you may press [^] (UP) or [**V**] (DOWN) key to increase/decrease the configured parameter value. The modified value is shown on the display, but the actual parameter value stays intact until you press [**DATA/ENTER**]-key to confirm the change.

Pressing [^] (UP) or [**V**] (DOWN) key modifies the displayed parameter value until the upper/lower parameter value limit is respectively reached.
While [**DATA/ENTER**] is not pressed, you may cancel any change by pressing [**ESC**]-key.
In both cases (accepting or canceling the change) you return to the upper (**PARAMERTERS**) Display level.

You are informed that parameter change is committed by a short display ‘wink’ after pressing [**DATA/ENTER**], while pressing [**ESC**] returns you instantly to the **PARAMERTERS** Display level.

NOTE : When in **PARAMERTER Modification** mode you press and hold the [^] (UP) or [**V**](DOWN) key, parameter value keeps on going up/down till the upper/lower parameter value limit. The increment of change increases with time, so the longer you keep the key pressed, the faster parameter value changes. This feature helps you set the needed new value in reasonably short time when making large changes.

4.6.2.5 **Operating Values Observation** Display

This is a special display mode which applies to the ‘Display Menu’ [**b**] only.
You enter this display level from **MENUS** Display level by pressing [**DATA/ENTER**]-key on condition that the [**b**]-menu is selected.

A set of operating values (parameters) may be monitored. You select the needed operating parameter by changing the operating parameter index.
Correspondence between operating parameters and indices is listed in the table below:

Table 4.9. – Operating Values

Index	Operating Value	Dimension
0	DC-bus Voltage	[V]
1	Motor Phase Current	[A]
2	Motor Synchronous Speed	[rpm]
3	Inverter Output Frequency	[Hz]
4	Drive System Status	[-]
5	Software Revision Number	[-]
6	Digital Inputs State	refer to **NOTE#1**
7	Digital Outputs State	refer to **NOTE#1**
8	Liquid Pressure	[-]
9	Output line-to-line Voltage	[V~]
10	Estimated Power Factor	[-]

When the **Operating Values Observation** Display level is entered, the present display index is shown for a while, and then respective operating value appears on the display. If the selected operating value is variable (for instance – the DC-bus voltage), the value changes are continuously shown on the display – the displayed value is automatically refreshed.

To go to the next operating value, you briefly press [**^**] (UP) key, to go to the previous one - **V**] (DOWN) key. In both cases (previous/next Operating Value selection), the respective Operating Value index is shown briefly before the value itself is displayed.
You cancel **Operating Values Observation** and return to **MENUS** Display by pressing the [**ESC**].

NOTE#1:
Digital Inputs/Outputs states (Index 6, 7) are shown in a special graphical way.
The state (Active / Inactive) of Each Input or Output is visualized through a pair of LED segments in a position, corresponding to this Input or Output in the 4-digit LED display.

Inactive Input / Output is designated through the lower segment in respective position – **|**

Active Input / Output is designated through both lower and upper segment – **|**

Four segment pairs correspond to four Digital Inputs displayed (listed from right to left):
- Analog Input configured as digital one (rightmost segment position)
- Digital Input 1
- Digital Input 2
- Digital Input 3

For instance, the condition where Digital Input 1 is active, while all remaining inputs are inactive, is shown below:

Four segment pairs correspond to four Digital Outputs displayed (listed from right to left):
- Digital Output 1 (rightmost segment position)
- Digital Input 2 (relay output)
- Pre-charge control internal output
- Fan control internal output

For instance, the condition where Pre-charge control output and the relay output are active, while the remaining outputs are inactive, is shown below:

NOTE#2:
When the **Operating Values Observation** mode is exited, the Display Index is kept till the next time this mode is entered, so the displayed value index is not changed.

4.6.3 Hidden Parameters Menu

Hidden parameters are a special set of parameters that under normal circumstances do not need to be modified by the customer. So, hidden parameters menu is not a part of the 'common' (explicit) menu/parameter layout and is not accessed in the usual way. Instead, a different procedure is designed to browse the hidden parameters and separate 'strong' password is needed to gain modification permission for hidden parameters (refer to paragraph **6.4** for details on Password Protection).

To access the Hidden Parameters Menu:

- In **MAIN** Display level, press [**ESC**]-key, then without releasing it, press the [^] (UP)-key.
  Then [**HP 0**] appears on the display, indicating that you are in the '**H**idden **P**arameters' menu and Hidden Parameter 0 is selected.
  You can traverse all hidden parameters in ascending/descending order using the [^] (Up) / [**V**] (DOWN) pair of keys. When the hidden parameter of interest is reached, you can press [**ENTER**/**DATA**] to view its configured value. Further action depends on whether 'strong' password has already been entered to acquire hidden parameter modification permission or not.

- if modification permission has been granted, you can proceed the usual way(described above for the explicit parameters), using [^] (Up) / [**V**] (DOWN) [**ENTER**/**DATA**] and [**ESC**] keys to modify the hidden parameter value and confirm or cancel modification.

- if no modification permission is present, then the [^](Up) / [**V**](DOWN) keys do not change the displayed value. Instead, they increase/decrease the hidden parameter number, so pressing [^]-key lets you see the value of the next hidden parameter, while pressing [**V**] shows you the value of the previous one. This is a convenient way of browsing the values of all parameters in this menu.

When you are done with hidden parameters browsing/modification, you return to **MAIN** Display level by consecutively pressing [**ESC**]-key.

ATTENTION

As already mentioned, hidden parameters modification is not a common procedure and normally is NOT performed by the customer.
So, we suggest that (if needed) it is done only with assistance from the manufacturer.

4.6.4 Password Protection

As incompetent parameters change may harm drive operation, modification of most configuration parameters is protected by simple password mechanism. The aim of this mechanism is to guarantee that parameters modification is performed only by a person, familiar with the drive system which is verified by performing certain procedure and knowledge of a simple password.

There are three access levels with three different passwords (password levels):
- password level **1** gives access to all explicit parameters
- password level **3** gives access to both explicit and hidden parameters (refer to paragraph **6.3** for explanation of explicit / hidden parameters concept)
- password level **2** is not used in this software version

To enter a password:
- In **MAIN** Display level press [**ESC**]-key, then without releasing it, press the [**V**] (DOWN)-key. In result, [**PASS**] inscription appears on the display.
- release the pressed keys, then press [**ENTER**/**DATA**]-key [**0**] appears in the rightmost display position.

- using the [^] (UP)-key (and, if needed, the [**V**](DOWN)-key), change the displayed parameter value to the needed access level password value, which for the present software revision is:
  - [**8**] for the password level **1**
  - [**88**] for the password level **2**
  - [**127**] for the password level **3**

- press [**ENTER/DATA**]

In case you have acquired Password Level **1**, then [**A**] appears in the leftmost display position – this indicates that you are now at **MENUS** Display level, from where you can navigate to the needed Menu and parameter and change the parameter value as described in previous paragraphs

In case you have acquired Password Level **3**, then [**HP 0**] appears on the display, which indicates that you are in the '**H**idden **P**arameters' menu and Hidden Parameter 0 is selected. You can navigate to the needed Hidden Parameter and change its value as described in previous paragraphs. You can also navigate to some explicit parameters menu and do appropriate modifications.

NOTE#1:
If you press [**ENTER/DATA**] with invalid Password value selected, then [**Eror**] appears on the display. Now you have a choice between pressing [**ESC**] to go back to **MAIN** Display level or pressing [**ENTER/DATA**] to try again setting a valid password value.

NOTE#2:
When valid password is entered, the system starts monitoring the keyboard activity. If more than 5 minutes without any keyboard activity elapses, then access rights are canceled. So after long periods without any key press, you'll have to enter the password again. You may also manually cancel access rights by repeating the Password-entering procedure and provide an invalid password value (for instance 0). Then, when [**Eror**] inscription appears, you just press [**ESC**] to go to **MAIN** Display level with access permissions taken away.

NOTE#3:
Modification of parameters **A.0** (output frequency set point) and **A.1** (minimal output frequency) is NOT protected by a password.

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